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ABSTRACT

Research has indicated that across the second to fifth grade range, there was evidence to suggest a difference between the oldest and youngest groups in the memory representations which directed recall of logically related sentences. The developmental trend was from what seemed to be an unstable and fragmentary memory rperesentation, which included inconsistent and contradictory information, toward a more stable, unified, and internally consistent representation which embodied both expressed and inferred information. (Author/CK)

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Logical Operations and Sentence Memory in Children [1, 2]

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Some psycholinguistic theorists regard sentence comprehension as an interpretive, analytic process, in which the listener analyzes the sentence linguistically and extracts some or all of the information it contained (e.g., Clark, 1969; Katz & Fodor, 1963). However, a rapidly expanding body of research indicates that comprehension is instead a highly constructive process, in which semantic representations are constructed by assimilating sentential information to the listener's knowledge system (e.g., Barclay, 1973; Bransford, Barclay, & Franks, 1972). The term "knowledge system" here refers to logical and other cognitive operations, as well as to information stored as concepts, facts, and so forth. Because semantic representations are constructed through the interplay of sentential information and an active knowledge system, these representations can embody more information than a sentence actually expressed. For example, the finished semantic product often contains implications or inferences derived from perceived sentences.

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To illustrate, consider an experiment by Barclay (1973). Adults were read a list of comparative sentences such as THE ARTIST IS TALLER THAN THE COWBOY, THE FIREMAN IS SHORTER THAN THE COWBOY, and so on. The putative task was to figure out the relative order of five men in terms of height. In the surprise recall task which followed, subjects recalled relatively few of the sentences actually presented. Instead, most of their recall responses were inferences. Responses categorized as inferences were either statements which were logically equivalent to presented sentences (a primitive sort of inference), or statements which resulted from transitive reasoning. For example, if

subjects had heard THE ARTIST IS TALLER THAN THE COWBOY and THE FIREMAN IS SHORTER THAN THE COWBOY as part of the list, they would erroneously remember having heard sentences like THE COWBOY IS SHORTER THAN THE ARTIST, a logical equivalent, and THE ARTIST IS TALLER THAN THE FIREMAN, a transitive inference. Finally, it is important to note that the proportions of various types of recall responses were highly predictable under the assumption that subjects had stored just an abstract representation of the constructed linear array plus a general sentence frame ("The (x) is (taller/shorter) than the (y)."). Apparently, no more specific information about individual sentences had been stored.

In the study just described, subjects processed a set of semantically related sentences, drew inferences from the information they contained, integrated all of the resultant information, and then stored a unified semantic entity which later guided recall. Clearly, this process is relevant not only to considerations of psycholinguistic theory, but also to typical learning situations involving linguistically transmitted information.

The present research was an initial investigation of the extent to which children perform similarly to adults in a situation approximating those used in Barclay's studies. Methodological details will be presented below, but for now simply note that the present task required children to solve transitivity problems on the basis of a few brief "clues" or premises. Following each solution, the subjects attempted to recall the clues, and their recall data in turn were taken to indicate the nature of the constructed memory representations.

A developmental investigation along these lines was considered worthwhile on the following grounds. On one hand, the construction of a holistic

memory representation which includes inferences could be an inherent component of linguistic processing, such that the tendency for inferences to intrude in recall shows no developmental trend over a sufficiently wide age span. On the other hand, perhaps the younger children, who have recently acquired a given logical operation, are less likely to spontaneously store inferences than are the older children, who are more practiced in the use of that operation. (A variation on this second theme is that children just becoming familiar with an operation which is inherently necessary for constructing a holistic array are perhaps unable to perform such a construction very well. As the operation becomes easier to perform, or is used more widely, their memory representations could become more unified and stable.) Thus, the tendency for inferences to intrude in recall would increase with age, rather than remain stable. These conflicting views depict different sorts of memory representations: in the extreme, one representation embodies both expressed and inferred information, and the other contains only expressed information. The present study was designed as an initial test of these two working hypotheses.

METHOD

The subjects, all of roughly equal and average intelligence, were drawn from the second, third, fifth, and sixth grades of a predominantly middle-class elementary school. Proportions of males and females were not balanced evenly either within or across grades, but inspection of the data revealed no hint of sex differences.

The experimental task included five transitive reasoning problems, set in the context of a detective game. Each problem involved three items ordered along a given dimension. For example, one problem required subjects to determine which of three men was the fastest runner. Three clues were given,

one of which was always redundant. In this case, the clues were: THE SAILOR IS SLOWER THAN THE MILKMAN; THE LAWYER IS FASTER THAN THE MILKMAN; THE MILKMAN IS FASTER THAN THE SAILOR. These clues permit a transitive inference, which could be stated either as THE SAILOR IS SLOWER THAN THE LAWYER or as THE LAWYER IS FASTER THAN THE SAILOR. For each problem, after the child had submitted his solution, he was asked to recall all of the clues.

Adding the redundant clue permitted better syntactic counterbalancing across the five problems, and helped to elicit more data by adding an extra sentence to be recalled.

RESULTS AND DISCUSSION

In order to ensure that all subjects in the final analysis were capable of transitive reasoning, only those who solved at least four of the five problems were included. The sixth graders' behavior during the task indicated that their performance was qualitatively different from that of the younger subjects; consequently, the sixth graders' data were analyzed separately.

Among the second, third, and fifth graders, the proportion of subjects giving at least one transitive inference during recall remained consistently high: .79, .79, and .94 respectively. On this measure, the difference between the fifth graders and the two younger groups approached, but did not reach, statistical significance (proportions test, $\underline{X}^2(1) = 2.70$, $p<.10$).

For finer analyses, the data were further restricted to include only subjects who gave at least one transitive inference in recall, leaving 15 subjects at each grade. Only recall responses following correctly solved problems were examined. For each subject, recall responses were divided into four categories: OLDs, sentences actually presented as clues; EQUIVALENTs,

sentences which were logically equivalent to the presented clues; TRANSITIVEs, transitive inferences derived from the clues; and FALSEs, sentences which were false with respect to the order among the three items on a given problem. For each subject, the proportions of his total responses falling into each of these categories were tabulated, and the results are presented in Table 1.

Insert Table 1 about here

A Grade by Sentence Type analysis of variance and appropriate post-hoc tests were carried out on the proportions, with the following major results. In general, evidence for a developmental increase in the tendency for inferences to intrude in recall is indirect but nonetheless interesting. The increase in the proportions of EQUIVALENTs across grades was not significant, and the proportions of TRANSITIVEs were nearly identical across grades. There was, however, one important difference between the second and fifth grade subjects: fifth graders gave significantly more EQUIVALENTs and TRANSITIVEs than FALSEs ($p<.05$); second graders gave significantly fewer EQUIVALENTs than either TRANSITIVEs and FALSEs ($p<.05$), with the latter two being equal. It is quite possible that for the youngest subjects, responses scored as EQUIVALENTs and TRANSITIVEs were actually just guesses, or in any event, not actually "inferences" as we have categorized them, since they are at the same proportional level as FALSE responses. Along these lines, note that the proportion of FALSEs did decrease significantly from second to fifth grade ($p<.05$). Furthermore, examining the data from incorrectly solved problems showed that the recall responses of the fifth graders were usually internally consistent while those of second graders were quite often inconsistent and mutually contradictory. Thus, there is sufficient evidence to suggest that second

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and fifth graders were basing their recall on different sorts of memory representations.

As for the third graders, their scores did not differ significantly from those of the second or fifth graders in any of the response categories. However, their performance was closer to that of the older subjects in that they submitted more TRANSITIVEs than FALSEs ($p<.05$), suggesting that responses classed as TRANSITIVEs for the third graders were in fact inferences, and not just guesses.

Finally, consider the results of the sixth graders. While those data appear to interupt the trends described for the younger groups, it was clear that for these oldest subjects, the task was neither challenging nor even interesting. They solved the problems quite easily, and often commented spontaneously on being bored with various aspects of the task. Only 60% of those who solved the criterial number of problems gave any transitive inferences in recall. When the data from all sixth graders who reached the problem-solving criterion were examined, a surprisingly high number of inconsistent and contradictory recall responses were found. In general, their performance was simply sloppy and disinterested throughout the task, and to compare their data statistically to the rest would be misleading.

In summary, across the second to fifth grade range, there was evidence to suggest a difference between the oldest and youngest groups in the memory representations which directed recall of logically related sentences. The developmental trend was from what seemed to be an unstable and fragmentary memory representation, which included inconsistent and contradictory information, toward a more stable, unified, and internally consistent representation which embodied both expressed and inferred information.

Footnotes

1. Presented at the meetings of the Society for Research in Child Development, March, 1973.

2. Preparation of this paper was supported in part by grants from the Council on Research and Creative Work, University of Colorado, and from the National Institute of Child Health and Human Development (HD06841-02).

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Table 1

Mean proportion of total responses in each recall category

	Recall Category			
Grade	Old	Equivalent	Transitive	False
2	.65	.06	.14	.17
3	.69	.08	.15	.08
5	.71	.12	.12	.04
6	.70	.09	.14	.06